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This Week's Citation Classic

McSkimin H J & Andreatch P. Analysis of the pulse superposition method for measuring ultrasonic wave velocities as a function of temperature and pressure. J. *Acoust. Soc. Amer.* **34**:609-15, 1962. [Bell Telephone Laboratories, Murray Hill, NJ]

The H.J. McSkimin pulse superposition (PSP) method of determining ultrasonic wave velocities in materials such as single crystals under pressure and temperature variations is developed and analyzed critically. This method, which takes into account the transducer coupling effect, greatly increased the range of measurement of accurate ultrasonic wave velocities. [The *SCI*® indicates that this paper has been cited over 140 times since 1962.]

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"This paper helps explain the details required to use the McSkimin PSP method[1] for measuring ultrasonic wave velocities in solids. McSkimin's 1961 paper on PSP showed how precision measurements of ultrasonic wave velocities could be determined to one part in 500 for round trip delays greater than five μsec. A subsequent paper[2] described methods of automatic frequency control with precisions better than one part in 10^6.

"PSP is useful for measuring absolute velocities *of* small specimens, in particular, single crystals. Calculations were made for a range of characteristic impedances which are likely to be encountered when measuring wave velocities in solids. The results shown in graphical form are helpful in applying the method to any material under test.

"The PSP method to obtain values of plane wave transit time in the presence of effects such as those produced by diffraction and coupling of the transducer to the specimen made possible the accurate determination of sound velocity and elastic properties. A chief motivation for the development of the method was to determine the small changes due to variations *of* pressure and temperature. This method allows one to separate the changes in transit time in the specimen itself from changes in transducer coupling and diffraction.

"Necessity may be the mother of invention but frequently implementation waits on technology. The first application of the PSP method for measuring ultrasonic wave velocities in solids was in determining delays of approximately one msec in wedge and polygon ultrasonic delay lines (1951). This technique was extended to delays of 100 μsec by 1954. However, it was not until the development of gas tubes that were capable *of* cyclical rates in excess *of* 400 KHz that the PSP technique could be seriously considered for small samples, and so another instant breakthrough spread over two decades *of* hard work.

"One reason this paper has been highly cited is that it was the most precise method available to measure ultrasonic wave velocities of single-crystal specimens. No method with this accuracy was available around 1960 and the equipment needed, such as the rf pulse generators, was not commercially available. Most of the equipment was developed by Thomas Bateman and McSkimin at Bell Laboratories, as were the methods *of* attaching the quartz-transducer to the specimens. More recent work has been reported in *Physical Acoustics: Principles and Methods.*[3,4]

"On November 28, 1979, McSkimin received the Silver Medal in Physical Acoustics for contributions to science and engineering through research in physical acoustics. One item mentioned in the award was the 'McSkimin pulse superposition technique' for measuring sound velocity and elastic properties in many single-crystal materials." [Herbert J. McSkimin died on February 20, 1981]

1. **McSkimin H J.** Pulse superposition method for measuring ultrasonic wave velocities in solids. *J. Acoust. Soc. Amer.* **33**:12-16, 1961.
2. ..... Variations of the ultrasonic pulse-superposition method for increasing the sensitivity of delay-time measurements. *J. Acoust. Soc. Amer.* **37**:864-71, 1965.
3. ..... Ultrasonic methods for measuring the mechanical properties of liquids and solids. (Mason W P, ed.) *Physical acoustics: principles and methods.* New York: Academic Press, 1964. Vol. I. Pt. A. p. 271-334.
4. **Moore R S & McSkimin H.** Dynamic shear properties of solvents and polystyrene solutions from 20-300 MHz. (Mason W P & Thurston R N, eds.) *Physical acoustics: principles and methods.* New York: Academic Press, 1970. Vol. VI. p. 167-242.